This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

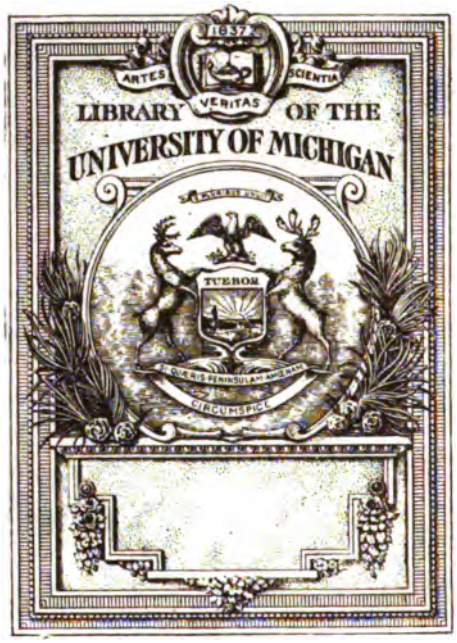
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 428272



Transferred to the

TC
425
.M66
M6
V58

62D CONGRESS, 3d Session } HOUSE OF REPRESENTATIVES { DOCUMENT No. 1223

Reports on Examination and Survey of Mississippi River

Between Winnibigoshish and Pokegama Reservoirs and from Leech Lake Dam to Mouth of Leech River, Minnesota

---

LETTER FROM
THE SECRETARY OF WAR

TRANSMITTING

WITH A LETTER FROM THE CHIEF OF ENGINEERS, REPORTS ON EXAMINATION AND SURVEY OF MISSISSIPPI RIVER BETWEEN WINNIBIGOSHISH AND POKEGAMA RESERVOIRS AND FROM LEECH LAKE DAM TO THE MOUTH OF LEECH RIVER, MINNESOTA, WITH A VIEW TO STRAIGHTENING AND IMPROVING THE CHANNEL

JANUARY 4, 1913.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with illustrations

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

62D CONGRESS, 3d Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 1223.

U. S. Engineer dept

MISSISSIPPI RIVER, BETWEEN WINNIBIGOSHISH AND POKEGAMA RESERVOIRS AND FROM LEECH LAKE DAM TO MOUTH OF LEECH RIVER, MINN.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING,

WITH A LETTER FROM THE CHIEF OF ENGINEERS, REPORTS ON EXAMINATION AND SURVEY OF MISSISSIPPI RIVER, BETWEEN WINNIBIGOSHISH AND POKEGAMA RESERVOIRS AND FROM LEECH LAKE DAM TO THE MOUTH OF LEECH RIVER, MINN., WITH A VIEW TO STRAIGHTENING AND IMPROVING THE CHANNEL.

JANUARY 4, 1913.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with illustrations.

WAR DEPARTMENT,
Washington, January 3, 1913.

SIR: I have the honor to transmit, herewith, a letter from the Chief of Engineers, United States Army, dated 31st ultimo, together with copies of reports from Lieut. Col. Francis R. Shunk, Corps of Engineers, with maps, on preliminary examination and survey, respectively, of Mississippi River, between Winnibigoshish and Pokegama Reservoirs and from Leech Lake Dam to the mouth of Leech River, Minn., made by him in compliance with the provisions of the river and harbor act approved June 25, 1910.

Very respectfully,

HENRY L. STIMSON,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, December 31, 1912.

From: The Chief of Engineers.
To: The Secretary of War.
Subject: Examination and survey of Mississippi River, between Winnibigoshish and Pokegama Reservoirs; and from Leech Lake Dam to mouth of Leech River, Minn.

1. There are submitted herewith, for transmission to Congress, reports dated January 7, and December 14, 1911, with maps, on preliminary examination and survey, respectively, of Mississippi River, between Winnibigoshish and Pokegama Reservoirs, and from Leech Lake Dam to the mouth of Leech River, Minn., with a view to straightening and improving the channel, authorized by the river and harbor act approved June 25, 1910.

2. The purpose of the desired improvement is in general to increase the efficiency of flow between the upper reservoirs at the headwaters of the Mississippi and Leech Rivers and Pokegama Lake, and to prevent the streams between these points from overflowing their banks at usual discharges.

3. The district officer presents a project for straightening the channels by means of cut-offs and dredging so as to obtain a ruling depth of 8 feet down to Pokegama, involving the excavation of about 2,000,000 cubic yards of material at a total estimated cost of $296 000, including $56,000 for construction of a dredge. Annual maintenance is estimated to cost $15,000. For the reasons given in his report, the district officer considers it desirable for the work to be done by hired labor with Government-owned plant if the project is adopted.

4. The district officer estimates that with this improvement a discharge of 1,500 cubic feet per second from Winnibigoshish and 1,200 cubic feet per second from Leech Lake would produce its full effect at Pokegama in 4 or 5 days instead of 21 days as at present, and with the better control of water between the reservoirs, the required depths could be maintained in the upper Mississippi and at St. Paul with much more certainty and with considerable saving in water; logging operations and steamboating could be carried on at the same time with much less interference and logs would no longer be carried over the bottom lands and left there when the discharge was reduced; and it would no longer be necessary to flood the meadows during hay-making time as is now done every low season to the great disadvantage of the farmers. While recognizing that these benefits are very great, the district officer believes they would be secured at too high a price, and therefore feels obliged to report that this work is not worthy of being undertaken by the United States at the present time.

5. The division engineer points out that the result of the improvement will be to reduce the time required to deliver water from Winnibigoshish and Leech Lake Reservoirs to St. Paul from 31 to 14 or 15 days, putting the center of the reservoir system about 13½ days from St. Paul instead of 27, or one-half the present time. Giving due weight to the other benefits to be anticipated from the work, he is of opinion that the proposed work is worthy of being undertaken by the Federal Government.

6. These reports have been referred, as required by law, to the Board of Engineers for Rivers and Harbors, and attention is invited to its report herewith, dated June 24, 1912, concurring in the favorable opinion of the division engineer.

7. After due consideration of the above-mentioned reports, I concur in general with the views of the division engineer and the Board of Engineers for Rivers and Harbors, that the gain in rapidity of delivery of reservoir water to the river at St. Paul will in this case justify the expenditure, and I believe this to be true even should the gain in time of flow not prove quite as great as estimated; and therefore in carrying out the instructions of Congress, I report as follows: That the improvement by the United States of Mississippi River, between Winnibigoshish and Pokegama Reservoirs, and of Leech River from its mouth to Leech Lake Dam, Minn., is deemed advisable so far as to secure the straightening of the channels by means of cut-offs, and obtaining a ruling depth of 8 feet, following in general the methods described in the report of the district officer at an estimated cost of $296,000, including $56 000 for the construction of a dredge and $15,000 annually for maintenance, these estimates being based on the supposition that the construction work will, as now seems desirable and advantageous, be prosecuted under a first appropriation of $116.000 and subsequent appropriation of about $60,000 per year for three years.

W. H. BIXBY,
Chief of Engineers, U. S. Army.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS ON SURVEY.

[Third indorsement.]

THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, June 24, 1912.

1. Respectfully returned to the Chief of Engineers, United States Army.

2. A survey having been made of the Mississippi River between Winnibigoshish and Pokegama Reservoirs, and from Leech Lake Dam to the mouth of Leech River, the district officer submits a project for improvement contemplating a ruling depth of about 8 feet at bank full stage. For convenience of consideration he divides the channel into three sections, the estimated excavation and expected carrying capacity of each being as follows:

	Carrying capacity per second.	Excavation.
	Cubic feet.	*Cubic yards.*
Mississippi River above its junction with Leech River	1,500	591,111
Leech River	1,200	522,222
Mississippi River below its junction with Leech River	2,700	815,741

The district officer states that should this work be let by contract it would scarcely be possible to get a lower price than 18 cents per yard. At a normal rate of progress, the work would require about

four years, and a dredge would be pretty well worn out in that time. He has therefore assumed that it would be economical for the United States to construct its own plant and do the work by hired labor. A suitable plant is estimated to cost $56,000, and with such plant it is estimated that the dredging could be done for 12 cents per cubic yard, or $240,000, making a total cost of $296,000. Annual maintenance is estimated at $15,000.

3. With the improved channel as outlined above, the district officer estimates that a discharge of 1,500 cubic feet per second from Winnibigoshish, and 1,200 feet per second from Leech Lake would produce its full effect at Pokegama in 4 or 5 days instead of 21 days, as at present, and the comparatively straight channels would considerably reduce losses by evaporation. Logs would no longer be carried over the bottom lands and left there when the discharge was reduced. Logging operations and steamboating could be carried on at the same time with much less interference. It would no longer be necessary to flood the meadows during hay-making time, as is now done every low season to the great disadvantage of the farmers. With the better control of water between the reservoirs, the required depths could be maintained in the upper Mississippi and at St. Paul with much more certainty and with considerable saving in water. The district officer recognizes that these benefits are very great; nevertheless, he believes that they would be secured at too high a price, and therefore he feels obliged to report that this work is not worthy of being undertaken by the United States at the present time.

4. The division engineer points out that the result of the improvement will be to reduce the time required to deliver water from Winnibigoshish and Leech Lake Reservoirs to St. Paul, from 31 to 14 or 15 days, putting the center of the reservoir system about 13½ days from St. Paul instead of 27, or one-half the present time. Giving due weight to the other benefits to be anticipated from the work, he is of opinion that the proposed improvement is worthy to be undertaken by the General Government.

5. There seems to be little doubt that benefits of a substantial character will be realized from the improvement, and this fact is recognized by both the district officer and division engineer. The work proposed is supplementary to the project for construction and operation of reservoirs at the headwaters of the Mississippi River, on which about $2,000,000 have already been expended, and it should aid appreciably in accomplishing the results for which that project was designed, though it is questioned whether the reduction in time of flow will be as great as it is estimated by the district officer. In view of this and other benefits to be derived from the work, the board joins the division engineer in expressing the opinion that it is advisable for the United States to undertake the project outlined within, at an estimated cost of $296,000 and $15,000 for annual maintenance. The initial appropriation should be $116,000.

6. There are no questions of terminal facilities, water power or other related subjects which could be coordinated with the work proposed in such manner as to lessen its cost and compensate the Government for expenditures made in the interests of commerce and navigation.

For the board:

WM. T. ROSSELL,
Colonel, Corps of Engineers,
Senior Member of the Board.

PRELIMINARY EXAMINATION OF MISSISSIPPI RIVER BETWEEN WINNIBIGOSHISH AND POKEGAMA RESERVOIRS; AND FROM LEECH LAKE DAM TO THE MOUTH OF LEECH RIVER, MINN.

UNITED STATES ENGINEER OFFICE,
January 7, 1911.

SIR: 1. In compliance with letter of the Chief of Engineers dated August 4, 1910, I have the honor to submit report on a preliminary examination of the Mississippi River between Winnibigoshish and Pokegama Reservoirs; and from Leech Lake Dam to the mouth of Leech River, with a view to straightening and improving the channel. I recommend that these streams are worthy of improvement to the extent of making a survey at a cost of $3,600.

2. Leech River and the portion of the Mississippi under consideration have not previously been examined with a view to improvement, but have been described in several reports, viz: Document No. 285, Forty-first Congress, second session, page 5; Document No. 19, (pt. 5) Forty-third Congress, second session, page 2; Document No. 54, Forty-fifth Congress, third session, page 19; and Annual Report of the Chief of Engineers for 1906, page 1472. The Mississippi River has been surveyed by the Mississippi River Commission, and Leech River by the Engineer Department in connection with the project for reservoirs, so that good maps exist. Measurements to determine discharge capacity were taken during the past season of heavy discharge, and have been used in connection with this examination.

3. The channels to be examined fall naturally into three sections, the Mississippi above its junction with the Leech, the Leech River, and the Mississippi River below the junction and above Pokegama.

4. The Mississippi River from Winnibigoshish Dam to the mouth of Leech River has a length by river of 19.5 miles. The distance along the axis of the valley is 13 miles. At high water, 1,500 cubic feet per second, the river has an average width of 150 feet, but is at some places less than 100 feet wide and in other places widens out into pools. The fall at this stage is 10.44 feet, giving a slope of 0.53 foot per mile. This is not, however, uniform, as there is a series of low rapids about six and a half miles (by channel) below the dam. The ruling depth at a discharge of 800 cubic feet per second is 3 feet. The bottom lands along the river have an average width of one-third mile.

5. Leech River from Leech Lake Dam to its mouth has a length by river of 26.8 miles and an average width of 125 feet, but its width is irregular. There are several large pools forming part of the river, and in places the channel is much contracted. The distance along the axis of the river is 17 miles. The bottom lands adjacent to the river are about one-quarter of a mile from bluff to bluff. The total fall at high stage, 1,200 cubic feet per second, is 12.02 feet, giving a slope of 0.45 foot per mile. The ruling depth at a discharge of 600 cubic feet per second is 3 feet.

6. The Mississippi River from Leech River to Pokegama has a length by river of 43.2 miles; along the axis of the valley the distance is 25 miles. The comparison of these lengths will show that the stream is very tortuous. Its average width at high water, 2,700 cubic feet per second, may be considered about 175 feet, but its width is very irregular and there are narrow places where the width

is about 75 feet. The total fall at high stage is 6.63 feet, giving a slope of 0.15 foot per mile. The ruling depth at a discharge of 1,400 cubic feet per second is 5 feet. The bottom lands are wide and there are many lagoons marking former locations of the channel

7. The improvement of these waters is desired in the interests of navigation under three aspects, namely logging, commerce on the waters in question, and the management of the reservoirs, which benefits such commerce as there is in the river from Pokegama to Lake Pepin, a distance of 402 miles.

8. Leech Lake Reservoir (capacity 33 billions of cubic feet) and Winnibigoshish Reservoir (capacity 45 billions of cubic feet) constitute the main part of the reservoir system. They discharge through the two streams in question. Any considerable increase or reduction in discharge, involving the flooding or draining of bottom lands, and the filling or emptying of lagoons and pools, is not felt in full at Pokegama for 21 days. Lesser variations when the rivers are empty require, by reason of the tortuousness and slight fall of the rivers, at least 10 days. The distances are 63 and 70 miles; yet below Pokegama, where conditions are better, water travels 128 miles to Aitkin in three to four days, depending on stage. The consequence is that water needed at St. Paul must be released a month beforehand, and the disadvantages of guessing for a month in advance are manifest. The quantity of water released in order to guard against insufficient depths often proves to be unnecessarily large, and there is never much to spare. Waste also results from the fact that the evaporation area is considerably increased. This was especially noticed during the past very dry season, when the water received at St. Paul bore a very unsatisfactory ratio to the amount discharged from the reservoirs. If the river could be kept in its banks the evaporation would be largely reduced. There is another supposed disadvantage of flooding the bottom lands. The mass of water between bluffs moves in the general direction, across loops and bends, and silts up the low-water channel. It is certainly a fact that the discharge capacity of the river is less than once it was, although from lack of records the exact amount of deterioration is uncertain. The Mississippi River below Leech River is now bank full at 1,400 cubic feet per second. The corresponding flow when the reservoirs were new is believed to have been 2,000 cubic feet per second. How much of this deterioration is due to flooding is doubtful, as some of it is caused by things incidental to logging operations. There is no doubt that the channels in question are the weak point of the reservoir system.

9. Logging is the chief industry in this part of Minnesota. Loose logs are sluiced through Leech and Winnibigoshish Dams and floated to Brainerd, Little Falls, or Minneapolis. The rivers below these dams and the Mississippi to Pokegama are so sluggish that the current in many places is insufficient to move logs, and they have to depend upon the wind as motive power; and a favorable wind is favorable only for a short distance, owing to the tortuosity of the streams. Since there are many shoal and narrow places jams are inevitable, and are so frequent that the normal mode of progress is from jam to jam. It requires three months to clear up the rear of a log drive from Winnibigoshish to Pokegama (63 miles) and only 20 days from Pokegama to Brainerd (179 miles). This comparison gives the best idea of the difficulties above Pokegama.

10. Whenever the river gets out of its banks during the logging season—that is, whenever water is required in the lower river during the dry season—logs are carried all over the bottoms and left stranded there, and there they must remain until next year unless water can be spared from the reservoirs to float them off.

11. The effect of loose logging in navigable streams may be seen in any river in Minnesota used for that purpose. Besides the immediate nuisance of the obstacle, jams induce secondary channels to open up, and sunken logs cause shoaling and spreading out of the water. I think that logging is partly responsible for the bad conditions which cause all interests to suffer.

12. Owing to the length of time required for a drive these waters are full of logs during almost all the navigation season. This is very detrimental to boat navigation, which is possible, as a rule, only on the lakes and wider parts of the Mississippi for 12 miles above Pokegama. In the upper reaches, although the channels have sufficient depths up to the dams, a boat, by watching its chance, can make a trip only now and then. Few complaints are made, because everyone realizes that logging is a good thing for the prosperity of the country; but all hands unite in desiring the improvement of the river.

13. The indicated remedy is to straighten the rivers, deepen them in shoal places, and cut off lagoons and secondary channels by suitable dams. The slope of the rivers, especially of the Mississippi below the Leech, is such that a good deal of straightening could be done without producing injurious velocities. The advisability of making the improvement depends on its cost and the value of the commerce to be benefited.

14. Commerce on the streams under discussion is carried on by the steamer *Undine*, 40 tons, and by 15 smaller steam and gasoline boats of business sizes. The value of the commerce can not be ascertained, as no figures are kept, but appears to be greater than the value of the commerce between Aitkin and Grand Rapids (viz, $150,000 per annum). Below Pokegama a boat makes regular trips to all points between Aitkin and Grand Rapids, carrying supplies to the farmers and bringing away produce. The business is profitable. Other smaller boats use the river. It is estimated that the commerce is worth about $150,000 a year. This commerce would be indirectly benefited by the proposed improvement. The commerce on the Mississippi River below the Twin Cities is estimated at 20,000 tons of freight per annum, valued at $1,600,000, and passenger traffic, the receipts of which are estimated at $100,000. This would also be materially benefited by improvement of the reservoir system. The logging business above Pokegama is valued at $5,000,000 a year.

15. In view of the facts above stated, I am of the opinion that Leech River and Mississippi River from Winnibigoshish to Pokegama are worthy of improvement by the United States to the extent of making a survey upon which estimates of cost can be based. Everything indicates that soundings and gaugings will be necessary, which can not be made until next summer. The estimated cost of the survey is $3,600.

16. The question of terminal facilities does not appear to enter the problem. The boats using the rivers are amply provided for at

private landing places. There are no public wharves nor provision for them. Power development is in no way affected. The proposed improvement would have some effect on floods, the amount of which can not be determined without survey.

Very respectfully,

FRANCIS R. SHUNK,
Major, Corps of Engineers.

The CHIEF OF ENGINEERS, UNITED STATES ARMY,
(Through the Division Engineer).

[First indorsement.]

OFFICE OF DIVISION ENGINEER, WESTERN DIVISION,
St. Louis, Mo., January 10, 1911.

Respectfully forwarded to the Chief of Engineers, United States Army, concurring in views and recommendation of the district officer as stated in paragraph 15.

W. L. FISK,
Colonel, Corps of Engineers,
Division Engineer.

[Third indorsement.]

THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, January 23, 1911.

1. Respectfully returned to the Chief of Engineers, United States Army.

2. As a result of his investigations in connection with the preliminary examination of Mississippi River between Winnibigoshish and Pokegama Reservoirs and from Leech Lake Dam to the mouth of Leech River, with a view to straightening and improving the channel, the district officer reports the locality worthy of improvement by the United States to the extent of making a survey upon which estimates of cost can be based. In this view the division engineer concurs.

3. It appears that the improvement contemplated would be of benefit to a small existing general commerce and to large logging interests, and more especially that it would tend to facilitate the operation of the reservoirs at the headwaters of the river and thus improve the conditions for general navigation on the upper Mississippi above Lake Pepin.

4. Believing that the advisability of the improvement depends upon its cost, the board concurs in recommending that a survey and estimate be authorized, and suggests that special attention be given in the report of survey to the relation of the proposed work to the system of reservoirs.

For the board:

WM. T. ROSSELL,
Colonel, Corps of Engineers,
Senior Member of the Board.

[Fourth indorsement.]

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, January 31, 1911.

1. Respectfully submitted to the Secretary of War.

2. This is a report on preliminary examination of Mississippi River between Winnibigoshish and Pokegama Reservoirs and Leech River between its mouth and Leech Lake Dam, authorized by the river and harbor act of June 25, 1910.

3. Inviting attention to the report of the Board of Engineers for Rivers and Harbors in the preceding indorsement, I recommend that a survey of the locality, as proposed, be authorized.

W. H. BIXBY,
Chief of Engineers, U. S. Army.

[Fifth indorsement.]

WAR DEPARTMENT, *February 1, 1911.*

Approved.

ROBERT SHAW OLIVER,
Assistant Secretary of War.

SURVEY OF MISSISSIPPI RIVER BETWEEN WINNIGIBOSHISH AND POKEGAMA RESERVOIRS AND FROM LEECH LAKE DAM TO THE MOUTH OF LEECH RIVER, MINN.

UNITED STATES ENGINEER OFFICE,
St. Paul., Minn., December 14, 1911.

SIR: In compliance with letter of the Chief of Engineers dated February 3, 1911, I have the honor to submit report of survey made of the Mississippi River between Winnibigoshish and Pokegama Reservoirs and from Leech Lake Dam to the mouth of Leech River, with a view to straightening and improving the channel.

2. A report of preliminary examination in the same manner was submitted to the Chief of Engineers on January 7, 1911. The survey made was not a complete topographical survey, but comprised only such measurements and determinations as were necessary for the specific purpose indicated. Maps of the Mississippi River Commission were available for the Mississippi River, but more detailed information was necessary, and a fairly complete survey was required along Leech River. Certain figures as to distances and slopes differ from those given in the preliminary report. The results of the survey, of course, are more accurate.

3. The purpose of the improvement is in general to increase the velocity of flow between the upper reservoirs and Pokegama, and to prevent the streams between these lakes from overflowing their banks at usual discharges. The desirability of the work is set forth in the prelimianry report. For convenience of consideration the channel is divided into three sections, as follows:

Mississippi River above its junction with Leech River.

Leech River.

Mississippi River below its junction with Leech River.

4. *Mississippi River above its junction with Leech River.*—Present low water conditions:

Channel length = 24.6 miles.
Fall=12.51 feet.
Average slope=0.58 foot per mile.
Distance along axis of valley=13 miles.
At discharge of 250 cubic feet per second the average width is 100 feet and the ruling depth is 2 feet.

It is sometimes desirable to make a discharge of 1,500 cubic feet per second from Winnibigoshish Reservoir. It is possible by cutting through bends and deepening shoal stretches (see map) to provide a channel 16.8 miles long which will have the desired capacity (1,500 cubic feet per second) at bank-full stage. The average slope will be increased to 0.74 foot per mile and the ruling depth at bank-full stage will be 8 feet.

5. To bring about this result the following dredging will be required:

	Cross section of cuts.	Linear feet.	Quantity.
	Sq. feet.		*Cubic feet.*
1 cut	200	1,100	220,000
8 cuts	400	3,900	1,560,000
3 cuts	600	5,100	3,060,000
25 cuts	800	13,900	11,120,000
Total (591,111 cubic yards)			15,960,000

6. *Leech River.*—Present low-water conditions:

Channel length=27.1 miles.
Fall=13.19 feet.
Average slope=0.48 foot per mile.
Distance along axis of valley=17 miles.
At a discharge of 500 cubic feet per second the average width is 100 feet and the ruling depth is 4 feet.

It is found that by cutting through bends and deepening shoal places a channel may be provided 19.2 miles long with a carrying capacity of 1,200 cubic feet per second at bank-full stage; the slope will be increased to 0.68 foot per mile, and the ruling depth at bank-full stage will be 8 feet.

7. The following dredging will be required in Leech River:

	Cross section of cuts.	Linear feet.	Quantity.
	Sq. feet.		*Cubic feet.*
3 cuts	200	1,900	380,000
5 cuts	400	2,300	920,000
4 cuts	600	2,800	1,680,000
18 cuts	800	13,900	11,120,000
Total (522,222 cubic yards)			14,100,000

8. *Mississippi River below the junction with Leech River.*—Present low-water conditions:

Channel length=40.3 miles.
Fall=8 feet.
Average slope=0.20 foot per mile.
Distance along axis of valley=25 miles.
At a discharge of 450 cubic feet per second the average width is 125 feet, with a ruling depth of 4 feet.

It is found that by cutting off bends and deepening shoal portions a channel may be provided 32.9 miles long (of which 7.9 will be virtually a lake) which will have a carrying capacity of 2,700 cubic feet per second at a little over bank-full stage, with an average slope of 0.32 foot per mile and a ruling depth of 8 feet.

9. In order to accomplish this result the following dredging will be required:

	Cross section of cuts.	Linear feet.	Quantity.
	Sq. feet.		*Cubic feet.*
5 cuts	500	4,700	2,350,000
2 cuts	750	2,100	1,575,000
22 cuts	1,000	18,100	18,100,000
Total (815,741 cubic yards)			22,025,000

10. The total amount of dredging required in the three sections will be as follows:

	Cubic yards.
Mississippi River above its junction with Leech River	591,111
Leech River	522,222
Mississippi River below its junction with Leech River	815,741
Total	1,929,074
Say	2,000,000

11. Should this work be let by contract it would scarcely be possible to get a lower price than 18 cents per yard. At a normal rate of progress, the work would require about four years, and a dredge would be pretty well worn out in that time. I have therefore assumed that it would be economical for the United States to construct its own plant and do the work by hired labor. I estimate the cost of plant as follows:

1 dredge, 40 by 120 feet scow, 2½ cubic yard dipper, 80-foot boom	$35,000
1 quarter boat, 18 by 50 feet	4,000
2 fuel barges, 20 by 100 feet, at $1,500	3,000
2 dump scows, 24 by 110 feet, at $2,000	4,000
1 steamboat dredge tender, 15 by 75 feet	9,000
1 gasoline tender, 35 feet	1,000
	56,000
With such plant the dredging could be done for 12 cents per cubic yard; the cost for dredging would therefore be	240,000
Making a cost, including engineering and contingencies, of	296,000

The improvement would require annual maintenance, estimated at 100,000 cubic yards of dredging per annum at 15 cents per cubic yard; the higher unit price being assumed, as the dredging will be scattered and in small quantities at a number of places. The annual cost of maintenance will therefore be $15,000.

12. With improved channel as outlined above, a discharge of 1,500 cubic feet per second from Winnibigoshish and 1,200 cubic feet per second from Leech would produce its full effect at Pokegama in 4 or 5 days instead of 21 days as at present. The cuts contemplated will not accommodate the largest probable discharge. It has happened in the past that 3,000 cubic feet per second have been drawn

from Winnibigoshish and 2,000 cubic feet per second from Leech. Such discharges would flood the bottom lands, but their frequency is not such as to warrant additional expenditure. The discharge contemplated—2,700 cubic feet per second—is to be expected almost every year. The projected improvement is therefore by no means an extreme or excessive one, but the least that would bring about a good condition of the channels in question.

13. The comparatively straight channels would carry the normal discharges without flooding adjacent swamps and wet meadows and thereby considerably reduce the losses by evaporation. Logs would no longer be carried over the bottom lands during a large discharge and left high and dry when the discharge was reduced. The logging interests would therefore be greatly benefited. With the improved channel it would be possible for logging operations and steamboating to be carried on at the same time with much less interference. In addition to these benefits it would no longer be necessary to flood the meadows during hay making, as is now done in every low season to the great disadvantage of the neighboring farmers. With the better control of water between the reservoirs, required depths could be maintained in the upper Mississippi and at St. Paul with much more certainty and with considerable saving of water.

14. These advantages are very great; nevertheless, the cost of the proposed improvement is so great that I doubt if it is advisable to undertake it at the present time. It is true that from the nature of the case a partial expenditure will produce partial results nearly in proportion to the amount of money expended. If a partial project were adopted it would be advisable to begin at Pokegama Dam and make the cuts in succession towards the upper reservoirs, as each cut would make its own proportionate amount of improvement in local conditions. Nevertheless, I am of the opinion that the benefits to be derived would be secured at too high a price. Assuming imaginary units of improvement, the cost per unit would be too high for the benefits to be expected. I am therefore obliged to recommend that this work is not worthy of being undertaken by the United States at the present time. I have reached this conclusion after mature deliberation and with considerable reluctance. It is quite probable that the improvement will be advisable at some future time, but in view of the comparative small value of the commerce to be benefited it does not seem proper to make so large an expenditure at present.

15. If the project be adopted it should be prosecuted at the rate of about 500,000 cubic yards per annum. The initial appropriation should be $116,000.

* * * * * * *

17. Statistics as to commerce are to be found in the report of preliminary examination, to which nothing need be added.

Very respectfully,

FRANCIS R. SHUNK,
Lieut. Col., Corps of Engineers.

The CHIEF OF ENGINEERS, UNITED STATES ARMY
(Through the Division Engineer).

[First indorsement.]

OFFICE OF DIVISION ENGINEER, WESTERN DIVISION,
St. Louis, Mo., December 21, 1911.

1. Respectfully forwarded to the Chief of Engineers, United States Army.

2. The views of the district engineer that the Mississippi River between Winnibigoshish and Pokegama reservoirs; and from Leech Lake Dam to the mouth of Leech River is not worthy of improvement by the General Government to the extent of $296,000 for dredging and $15,000 annually for maintenance are not concurred in by the division engineer.

3. The Government has already expended about $2,000,000 for the construction, maintenance, and operation of reservoirs near the headwaters of the Mississippi River. Of these reservoirs there are now five in operation, the annual cost of operation and maintenance being about $15,000, exclusive of renewals.

4. Their efficiency or lack of efficiency depends largely on their ability to deliver water when and where needed. Taking the five now in operation, their capacities in billions of cubic feet, and their distances from St. Paul, are as follows:

Reservoir.	Capacity.	Distance.
		Days.
Winnibigoshish	45	31
Leech Lake	33	31
Pokegama	5½	10
Sandy Lake	3⅜	7
Pine River	7⅛	6

By multiplying each capacity by its distance from St. Paul summing the products, and dividing that sum by the total capacity, it will be seen that the whole completed system equals one reservoir with a capacity of 94⅛ billions of cubic feet of water and located 27 days from St. Paul.

5. The result of the expenditure of $296,000 for improvement and $15,000 per year for maintenance will be to reduce the distance from Winnibigoshish and Leech Lake reservoirs (to be made one reservoir by a canal for which Congress has provided funds) to St. Paul so that it will be 14 to 15 days instead of 31. By multiplying and dividing as in the preceding paragraph the result will show that the improvement under consideration will put the center of the reservoir system about 13½ days from St. Paul instead of 27—or one-half the present distance. This will give the reservoirs the opportunity they have always needed—a fair chance to show their full efficiency.

6. In addition to the saving of time in delivering water there are other advantages to be considered:

(*a*) At present there is great loss of water by evaporation, due both to the great length of time elapsing between its discharge and its arrival at St. Paul, and to the flooding of large areas which expose great surfaces to atmospheric action. (*b*) There is undoubtedly a deterioration going on in the present channel (see par. 8 of the report of the preliminary examination). (*c*) The largest navigation interest

(logging) suffers from the slow current, from the unsatisfactory condition of the channel, and from the loss of logs in the flooded lowlands. (*d*) Steamboat navigation is interfered with by the long detention of logs and the formation of jams in this part of the river. (*e*) The farmers are greatly inconvenienced by the flooding of their lands even at the normal discharge.

7. In the opinion of the division engineer, the Mississippi between Winnibigoshish and Pokegama Reservoirs and from Leech Lake Dam to the mouth of Leech River is worthy of improvement by the General Government to the extent of $296,000 for dredging and $15,000 for annual maintenance.

8. The recommendations of the district engineer (pars. 11 and 15) as to the method of doing the work and the amount of the first appropriation are concurred in.

CHAS. L. POTTER,
Lieut. Col., Corps of Engineers,
Division Engineer.

[For report of the Board of Engineers for Rivers and Harbors on survey, see p. 3.]

SUPPLEMENTAL REPORT ON SURVEY OF MISSISSIPPI RIVER BETWEEN WINNIBIGOSHISH AND POKEGAMA RESERVOIRS, AND FROM LEECH LAKE DAM TO MOUTH OF LEECH RIVER, MINN.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., March 15, 1912.

SIR: 1. In compliance with 1st indorsement on letter [1] of January 30, 1912, from the Board of Engineers for Rivers and Harbors I have the honor to submit the following supplemental report on the survey of the Mississippi River between Winnibigoshish and Pokegama Reservoirs; and from Leech Lake Dam to the mouth of Leech River, with a view to straightening and improving the channel.

2. The closing of lagoons and secondary channels spoken of in paragraph 13 of the preliminary report of January 7, 1911, would be accomplished by deposit of dredged material. This material is mostly bog, firmly bound together by roots of coarse grass and reeds, which resists erosion very well. When deemed advisable, brush, of which there are large quantities along the river, could be mixed in with the dredged material. There is no rock in the vicinity.

3. The nature of the soil is such that a dipper dredge would be the most suitable for the work. The dredged material would, in general, be deposited in spoil banks along each side of the dredged channel, a sufficiently long dipper boom being provided to give a wide berm.

4. The computations from which the reduction of time of transit of discharge waves is deduced are based on the assumption that the ordinary flow from Winnibigoshish Reservoir is 900 cubic feet per second, and from Leech Lake Reservoir, 700 cubic feet per second, making a total of 1,600 cubic feet per second. The records of this office indicate that under these conditions the first effect of an increase or decrease in the discharge from the two upper reservoirs is felt at Pokegama in about 10 days and the full effect in about 21 days after the change. Varying conditions affect this time. Large

[1] Not printed.

changes in discharge are felt at Pokegama more quickly than small changes. Changes at high stages are felt more quickly than at low stages. The wetness or otherwise of the adjacent meadows on account of rainfall or lack of it, will correspondingly affect the rate of progress of any change.

5. The reservoir capacity formed by river channels, overflowed lands, sloughs, and connecting lakes, between the three reservoir dams can not be accurately given without further surveys. Approximately, however, it can be stated that at the stage of assumed ordinary flow the present area (exclusive of Pokegama Lake) is 269,000,000 square feet; the proposed improvement would reduce this to 237,000,000 square feet. The percentage of reduction is not very great. This is because on the line of improved channels there will still be two lakes, namely, Mud Lake and Little Winnibigoshish, which will continue to affect the discharge. Outside of these lakes the streams are almost entirely confined to their banks. It is not considered necessary to include the area of Pokegama Lake in these figures for the reason that the outlet of the lake is of much smaller capacity than the river at that point. This outlet is only about 3 miles distant from Pokegama Dam and during heavy discharges from that dam the resulting slope between the dam and the lake outlet is so great that almost all of the increased discharge from above goes directly to the dam.

6. To increase the discharge at the assumed ordinary flow to bank-full stages above the mouth of Leech River (Mississippi River, 1,500 cubic feet per second, and Leech River, 1,200 cubic feet per second), would require an increase of 600 cubic feet per second from Winnibigoshish Reservoir and 500 cubic feet per second from Leech Lake Reservoir, a total of 1,100 cubic feet per second. If the river channels had a sufficient carrying capacity, this discharge would produce a rise of 2 feet over the entire reservoir area of 237,000,000 square feet in about five days. If improved as proposed the channel below the mouth of Leech River should carry this increase of 1,100 cubic feet per second, or a total of 2,700 cubic feet per second, at about a bank-full stage, as shown by the formula

$$v = C\sqrt{rs}$$

in which

$C = 75$ (rough earth)

$r = 1500 \div 162.5 = 9.2$

$s = 0.32 \div 5280 = 0.0000606$

therefore

$$v = 75\sqrt{9.2 \times .0000606} = 1.77 \text{ feet per second.}$$

7. The application of formulas is subject to great uncertainties, but making the best assumptions possible the formulas give a velocity in the improved channel of not far from 1 mile per hour. Supposing this to be accurate, the total time of transit between the upper reservoirs and Pokegama would be 65 hours. Making allowances for inaccuracy and such lakes, lagoons, etc., as remain, I assume that the time required will be about five days, but this figure is not put forward as being at all as accurate as the figures for the present discharge which are based upon actual observation.

8. The passage of discharge waves is delayed on account of the necessity of filling up the intervening storage areas. Therefore, when quick results are desired with moderate discharge, the initial

discharge from the two upper reservoirs should for a few days be about twice the amount needed at Pokegama. In this way the difficulty in getting a stated increase to Pokegama in the minimum time could be overcome. In such cases it would frequently be necessary to overflow meadows, but that would be of little consequence as the Government owns flowage rights and the flooding of meadows for a few days would not affect uncut grass.

9. As previously stated an increase in the discharge from the two upper reservoirs, under present conditions, usually becomes noticeable at Pokegama in about 10 days, and its full effect is gradually reached in about 21 days. This rate varies under different conditions, and the factors entering into the situation are so complex that it is impossible to give positive information. As a rule the rate of increase at Pokegama progresses uniformly until the maximum is reached.

Very respectfully,

FRANCIS R. SHUNK,
Lieut. Col., Corps of Engineers.

The CHIEF OF ENGINEERS, UNITED STATES ARMY.

LETTER OF MISSISSIPPI AND RUM RIVER BOOM CO.

MISSISSIPPI AND RUM RIVER BOOM CO.,
Minneapolis, Minn., December 30, 1911.

GENTLEMEN: It has just come to our knowledge that a report adverse to the proposed improvement of the upper Mississippi River between Pokegama Dam and Lakes Winnibigoshish and Leech has been made to you by Lieut. Col. Shunk of the Corps of Engineers at St. Paul.

We desire, briefly, to state some reasons why, in our judgment, this improvement should be made. The current of the river at present is exceedingly sluggish, owing to the almost innumerable sharp bends in it, and the driving of logs is an exceedingly tedious process. Last season the rear of the drive was turned over Pokegama dam about September 20, notwithstanding driving had been going on practically all summer. These logs could not be driven beyond Brainerd this year and consequently must be carried over to next year before they can be sawed. This necessitates the carrying of a year's stock of logs ahead each year in order to keep the mills supplied.

The experience of the past season does not differ from others of many years past except possibly that the river reached Pokegama Dam somewhat earlier than usual. With a straightened channel from these lakes to Pokegama Dam the driving should not exceed from 20 to 30 days and in such case the logs could be utilized the same year.

This company, together with the Northern Boom Co. (an allied company), handles all the logs in the Mississippi River from Pokegama Dam to Minneapolis and has done so for many years. It is true that the logging interests are declining but are likely to continue in a less degree for some years to come.

We have referred only to the logging interests, but we believe other interests using water would be equally benefited by the proposed improvement.

The use of water in making electric power is in its infancy as yet and we believe the general interest of the people demands the straightening of the upper river in order that the water from the reservoirs may be more speedily and regularly distributed to points below.

We understand Col. Shunk opposes the improvement because of its cost. The present survey, as we are informed, follows the river. We would suggest that a survey be made to ascertain whether it would be practicable to utilize Ball Club Lake as a part of the course by cutting a channel from the upper end of that lake to the river above instead of following the river. We are informed that the distance from Deer River to Winnibigoshish is some 70 miles by river, while in a direct line it is only some 17 miles. It may not be practicable to do this, but if so, it would save a good many miles and probably reduce the cost materially.

We respectfully urge that the improvement be made, not alone for the logging interest, but for the general interest.

Yours, respectfully,

MISSISSIPPI AND RUM RIVER BOOM CO.,
R. H. CHUTE, *Treasurer and Manager.*

The BOARD OF ENGINEERS FOR RIVERS AND HARBORS.

LETTER OF MR. W. D. WASHBURN.

MINNEAPOLIS, MINN., *January 2, 1912.*

GENTLEMEN: My attention has been called to a circular notice dated December 14, 1911, by Lieut. Col. Francis R. Shunk, of the United States Engineers' office, at St. Paul, Minn., relative to proposed improvements of the Mississippi River between Winnibigoshish and Pokegama Reservoirs, and from Leech Lake Dam to the mouth of Leech River, with a view of straightening the river channel.

I note that after surveys, authorized by the Secretary of War under the provisions of an act of Congress of June 25, 1910, having been made, the report submitted is unfavorable to these improvements, although it is admitted that the same would be of great benefit.

I deeply regret that such a view of this matter has prevailed and would respectfully beg leave to request your honorable board to give this matter earnest consideration with the intention to ascertain if, after all, the benefits to be derived will not be worth the expenditure, and if not at once then surely in the future.

Then again I would beg leave to request your board to determine if it is not possible to reduce the expenditure for this improvement by connecting with a channel Little Winnibigoshish Lake with Ball Club Lake which lakes are only about 1 mile apart, and thus reducing largely the length of channel necessary to the straightening of the present river between the outlet of Little Winnibigoshish and the junction with Leech Lake River.

I am reliably informed by log owners and lumbermen that such a scheme may be possible and would give important additional benefits to the navigation of logs and their storage in Ball Club Lake. At any rate a careful survey should be made which would determine if there is any merit in this proposition before all prospects of making these river improvements at this time are abandoned.

I believe, gentlemen, that any reasonable expenditure made by the United States Government, with a view to improve the efficiency of the existing reservoirs on the Mississippi River, will be of commensurate benefit in more than one direction, even at the present time when navigation is not yet what it surely will be in years to come. This great river, upon whose shores population is steadily increasing, must some day be a great waterway of our country.

This I firmly believe, and while I may not at my advanced age live to see the full benefits of these reservoirs which I pride myself with having fathered during my service in the House of Representatives and the United States Senate, I desire to do all I can to have their usefulness and efficiency not only maintained but increased, if possible.

The proposed improvements, in my opinion, would increase the efficiency of these reservoirs owing to their ability to deliver water when and where needed in much less time than it can be done under present conditions. Then, the now enormous evaporation in warm weather would be largely diminished and in cold weather the abnormal formation of ice frustrated, due both to the great distances between terminals and the very sluggish run of the river over many miles of land physically adapted to handicap desired results. Periodical overflows of large areas of lands would certainly stop if these improvements were made. Anyone who is at all familiar with the circuitous and crooked river bed connecting these reservoirs, will tell you what a hindrance it is to navigation of logs and boats and how it interferes with the proper and prompt discharge of water when needed farther down the river.

If these reservoirs had no other usefulness whatever outside of their ability in preventing or mitigating floods at points below, they would be worth every dollar spent for their establishment by the United States Government. That there are other benefits can not be denied; as a matter of fact the Government rarely makes appropriations for public works without oustide interests receiving greater or less benefits. This is in the nature of things, and while such benefits, in most cases, are purely incidental, they are nevertheless of value for the general public in one way or another.

By giving the foregoing remarks your kind attention you will oblige me greatly.

I remain, gentlemen,

Yours, very respectfully, W. D. WASHBURN.

The BOARD OF ENGINEERS FOR RIVERS AND HARBORS.

LETTER OF NORTHLAND PINE CO.

NORTHLAND PINE CO.,
Minneapolis, Minn., January 4, 1912.

GENTLEMEN: We have a communication from Maj. Francis R. Shunk, of the United States Engineers' office, St. Paul, Minn., in reference to the proposed improvement of the Mississippi River between Winnibigoshish and Pokegama Reservoirs and Leech River from Leech Lake Dam to the mouth of said river. He states: "While it appears that the proposed improvement would be of great benefit, yet its cost is so high that it does not seem proper to recommend it at the present time in view of the comparatively small value of the commerce to be benefited."

Viewing the matter from a practical standpoint, and being thoroughly familiar with the conditions along said rivers, we can not agree with Maj. Shunk in reference to the benefit that would be derived from said proposed improvements. We are not prepared to state the amount that it would cost to make the improvements, but this no doubt has been very carefully gone over and determined by the department. We think, however, that the benefit to be derived has been very materially underestimated.

We have been driving logs down these two streams for a number of years and know something as to what it costs to float logs down the Mississippi River in its present condition. It now takes us from either Winnibigoshish or Leech Lake Dam to Pokegama Dam about 90 days on an average to make the drive of logs. If the proposed improvements were made, these same drives could be delivered to Pokegama Dam in at least 30 days or less. We have approximately 150,000,000 feet of logs to be driven down this stream in the next five years, being timber which we purchased from the United States Government on the Indian reservation. From this you can readily see the enormous saving to us in the way of expense in making the drives.

In addition to this we would be able to save the interest on our investment in the logs for six months to a year as, under existing conditions, logs driven down in this stream get over Pokegama Dam so late in the season that we are unable to get them to Minneapolis early enough to saw the same season in which they are put in. Then again we lose quite a percentage by shrinkage of logs sinking on account of being in the water so long.

Without giving you any exact figures, this will give you some idea at least of the amount that we ourselves would save if the improvement was made. In addition to us there are a great number of others who have logs coming down the same stream, under the same conditions, and they would save the same amount that we would. We should say that in the next five to seven years there are approximately 250,000,000 feet of logs to be floated down this stream.

In addition to this there would be a great benefit to the settlers along the Mississippi River if the improvements were made, as it would make the river navigable and there is no doubt but what small boats would go on the river between Pokegama Dam or Winnibigoshish and Leech Lake, which would save a great deal in the way of delivering supplies to the settlers and in the marketing of their products.

Taking up the next phase of the situation as we see it, and as we have watched the handling of these reservoirs, we are confident that the efficiency of the reservoirs is only about half what it would be if the said improvements were made. We are confident that if the improvements were made that you would be able to deliver water to St. Paul from either Winnibigoshish or Leech Lake Reservoir in not to exceed 20 days, where it now takes from 40 to 60 days.

In addition to this, owing to the very crooked course of the river and the condition of the channel, the evaporation is something enormous and we would not really dare to make any estimate of the enormous amount of waste of water on this account.

On account of the above reasons we would urge that the improvements proposed be made and as quickly as possible, believing that the returns would more than warrant any expenditures which might have to be made in making the proposed improvements. We would ask that you give this your very careful consideration, and urge the authorization of the improvements.

Very respectfully,

NORTHLAND PINE CO.,
By C. A. BARTON, *General Manager.*

The BOARD OF ENGINEERS FOR RIVERS AND HARBORS.

○

UNIVERSITY OF MICHIGAN
3 9015 06718 5739